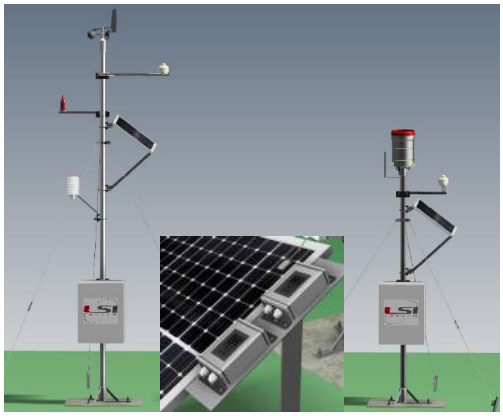

LSI
LASTEM
Environmental
Monitoring Solutions
SOLAR ENERGY
Monitoring equipment
Meteorological station for
PV application
Field system for PV Performance
Ratio application

For an operating Photovoltaic Plant, the main exogenous limitation to optimal performance is represented by the environmental conditions and by soiling presence on the PV module surfaces. The main environmental parameters as solar radiation, the basic feedstock of the system, and temperatures, influence performances of the plant, and less-heralded factors such as wind speed, wind direction, rainfall, concur to generate the environmental conditions determining the potential expected plant yield against which actual plant performances are measured. For this reason monitoring of the environmental characteristics of the site and, on the other hand, of the PV module itself, can give parameters to calculate the efficiency of the power plant. The key variables to be monitored are: global irradiance, air temperature and module temperature, diffuse irradiance. Also wind speed, wind direction, rain and storm distance are key factors in the field of risk prevention during extreme events.

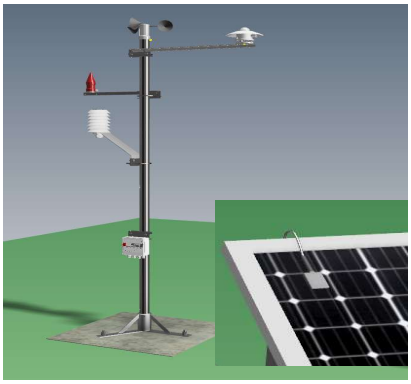
Meteorological station for PV application

A meteorological station designed for environmental monitoring in PV plants. Sensors for Performance Ratio calculation (Pyranometer, Air Temperature, PV module Surface Temperature) are accompanied by a Diffuse Irradiance, Wind Speed and Wind Direction Sensor or a Storm Distance Sensor and a Rain gauge for rainfall. System for soiling monitor can be integrated.



Field system for PV Performance Ratio application

Modbus Sensor Box module is the simplest and fastest way to connect environmental sensors to PLC/SCADA systems by Modbus RTU. The module can be easily interfaced to Global Irradiance sensors, each with its own sensitivity value, temperature sensors (Air and PV module surface), wind speed and storm front distance sensors.



The standard IEC 61724-1:2017 Photovoltaic system performance – Part 1: Monitoring

The 61724-1 standard for monitoring the performance of photovoltaic fields of 2017 defines "accuracy classes" for the measurement systems of the monitored variables. The class is not only determined by the hardware used and the accuracy of the measurement, but also by the quality controls and measurement procedures.
The standard also details the number of instruments to be set up according to the power of the plant and the frequency of calibration and maintenance of the instruments, with the aim of minimizing measurement errors.

The standard introduces these fundamental principles:

- **3 accuracy classes, A, B and C**, for monitoring systems
- accuracy requirements for monitoring systems depending on the class
- **frequency of calibration and maintenance** by class
- recommended **minimum number of instruments** used according to the size of the PV plant

The meteorological variables for evaluating the efficiency of the photovoltaic system reported by the standard are not only those relating to **solar radiation**:

- Irradiation on the module plane (POA)
- Global horizontal irradiation (GHI)
- Normal direct radiation (DNI)
- Diffuse radiation (DHI)

But they also concern **boundary climatic factors** that can affect the performance of the system

- Photovoltaic module temperature
- Ambient air temperature
- Wind speed and direction
- Dirt on the panel
- Rain
- Snow
- Relative humidity

In order to be classified as Class A, B or C, the monitoring systems must meet several characteristics. As for the **pyranometers** used for measuring global irradiation, the following table shows the main characteristics required:

Characteristic	Class A	Class B	Class C
Pyranometer type	Spectrally Flat Class A	Spectrally Flat Class B	Any
Recalibration	Every year	Every 2 years	As specified by manufacturer
Cleaning	Every week	Optional	-
Heater	Required in locations with freezing precipitation > 7 days / year	Required in locations with freezing precipitation > 14 days / year	-
Ventilation	Required	Opztional	-

As regards the measurement of the **other climatic quantities**, the following characteristics are described:

Variable	Characteristic	LSI LASTEM* Sensor	Class A	Class B	Class C
PV module Temperature	Required	**DLE124A**	**Yes**	**Yes or estimated**	-
	Accuracy	0.15°C	< 2°C		
	Recalibration		Every 2 years	As specified by manufacturer	-
Air Temperature	Required	**DMA033A**	**Yes**	**Yes or estimated**	-
	Resolution	0.01°C	0.1 °C		
	Accuracy	0.1°C	± 1°C		
	Recalibration		Every 2 years	As specified by manufacturer	-
Wind speed	Required	**DNA202.1**	**Yes**	**Yes or estimated**	-
	Accuracy	0.12 m/s@<5m/s 2.5%@>5m/s	< 0.5 m/s @ <5 m/s < 10% @ >5 m/s		
	Recalibration		Come da produttore		-
Wind direction	Required	**DNA212.1**	**Yes**	-	-
	Accuracy	<1%	5%		
	Recalibration		As specified by manufacturer		
Module soling	Required	**DPA048.1**	**Yes**	-	-
	Cleaning freq.		Every day	Less frequent	
	Recalibration		Every year		
Rainfall	Required	**DQA230.1**	**Yes**	**Yes or estimated**	-
	Accuracy		-	-	-
	Recalibration		-	-	-
Snow	Required	**DQL011.1**	-	-	-
Humidity	Required	**DMA672.1**	-	-	-

** LSI LASTEM sensor models that can be used in photovoltaic applications able to satisfy Class A according to the **IEC 61724-1: 2017** standard*

Field calibration system for radiometric sensors

- Full compliance with ISO9847 "Field calibration of pyranometers for comparison to reference pyranometer"
- Portable, self contained and easy to use system
- Allows simultaneous calibration from 2 to 12 sensors
- Direct reading of the sensitivity value (calibration factor) obtained
- It can also be used for the calibration of photovoltaic cells
- Calibration report according to ISO9847

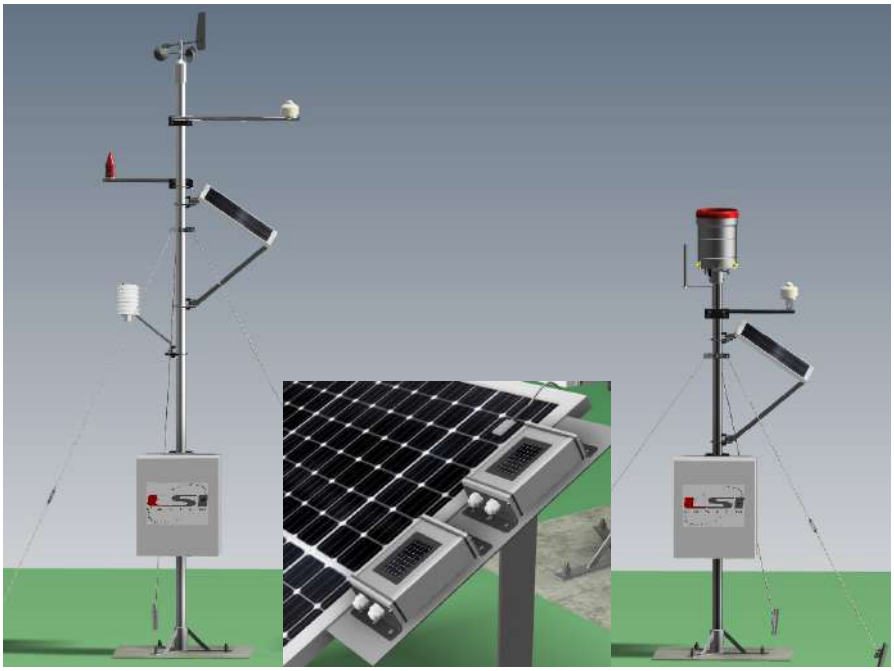
LSI Lastem sensors are able to cover all the environmental monitoring requests of photovoltaic systems as compliant with the IEC 61724-1: 2017 standard (excluding heating for Spectrally Flat Class B pyranometers).

The standard places an important emphasis, more than on the technical characteristics of the sensors and the relative accuracy, on the need for the plant manager to ensure a check on his instruments and **frequent recalibration**.

In this regard, LSI Lastem provides on-site recalibration of pyranometers both in the form of service and with the possibility of purchasing a dedicated kit.

On-site calibration is performed under direct sunlight under clear skies. The kit includes a reference sensor (Secondary Standard), an air temperature probe and the data logger (M-Log or E-Log) in a variable number based on the number of sensors to be calibrated (3 or 8 sensors). There are a series of accessories for fixing the different parts and for their transport. The data logger is set to directly calculate the **calibration factor** for each sensor with output in Volts: this value is reported in the calibration report provided.

Meteorological station for PV application



- Sensors for the calculation of PV plant
- Meteorological parameters monitoring with several available sensors
- Data storing for further analysis
- Risk protection during extreme events thanks to wind speed and direction sensors and storm distance sensor
- Modbus RTU or Modbus TCP for connection to PLC/SCADA system
- Connection by Modem to remote servers
- Configurable thresholds to generate alarms through SMS, E-mails or activation of local devices with electrical outputs

A meteorological station designed for environmental monitoring in PV plants. Sensors for Performance Ratio calculation (Pyranometer, Air Temperature, PV module Surface Temperature) are accompanied by a Diffuse Irradiance, Wind Speed and Wind Direction Sensor or a Storm Distance Sensor and a Rain gauge for rainfall. Global Irradiance is the most important climatic parameter for the evaluation of the photovoltaic plant performance and in this regard, LSI Lastem provides pyranometers with different classifications: Spectrally Flat Class A, B and C according to ISO9060:2018 standard (see the Table below and also MW9000-ENG-11catalogue). State of the art ventilated and heated Spectrally Flat class A pyranometers are also available. System for soiling monitor can be integrated. This station is normally connected by Modbus RTU or Modbus TCP to the plant SCADA system, but at the same time it can store the measurements and send them to one or several remote servers, produce alarms by SMS, Email and trigger, using electrical output, local devices in case of particular events.

PN Models with direct output	DPA252	DPA154A	DPA053
PN Models amplified 4÷20mA version	DPA952	DPA855	DPA863
PN Models with Modbus output	DPA953	DPA980	DPA983
ISO9060 Classification	Spectrally flat Class A	Spectrally flat Class B	Spectrally flat Class C
Daily total uncertainty	±2%	±5%	±10%
Spectral range	285÷3000 nm	285÷3000 nm	285÷3000 nm
Output (sensitivity)	7÷25 μV/W/m^2	10÷15 μV/W/m^2	10÷15 μV/W/m^2
Response time (95%)	4,5 s (3 s only DPA953)	20 s	16 s
Zero-offset due to temperature varia-	±2 W/m^2	±3 W/m^2	±4 W/m^2
Directional response	<±10 W/m^2	<±20 W/m^2	<±20 W/m^2
Non-linearity	<±0,2% (100÷1000 W/m^2)	<±1%(100÷1000 W/m^2)	<±1,2%(100÷1000 W/m^2)
Stability (% change/year)	<±0,5%	<±1%	<±1,5%
Temperature response	<±0,4% (-30÷50°C)	<±4% (-10÷40°C)	<±4% (-10÷40°C)

Contact Temperature sensor

Pt100 sensors are available for the measurement of contact temperature of photovoltaic modules with 1/3 DIN (0,1°C) accuracy. They are provided with 4-wires L=20 m cable. Sensors are easily connected to photovoltaic modules by means of a thermo conductive paste and supporting strip.

Air Temperature sensor

Meteorological air temperature sensor protected by antiradiation screen from the direct radiation. The sensor's accuracy is 1/3 DIN (0,1°C) for temperature. It is equipped with 4-wires cable. Temperature and Relative Humidity (%) sensor is also available.

Wind Speed and Direction sensor

Wind affects the natural cooling of the PV modules. Wind monitoring is also important because significant wind load can reduce the module stability mainly in case of solar concentrator or adjustable solar panel systems.

Storm Front Distance sensor

Since PV plants are sensible to lightning activity, this sensor can help reducing the risk detecting the storm front distance within an area of in 5÷40 km range. Utilizing a sensitive RF receiver and integrated proprietary algorithm, detects the electrical emissions.

Rain gauge

When it is raining there is clouds coverage reducing the system production. But rain washes away dirt and debris, essentially giving good cleaning to the panels. Rain can also effect the overall stability of the PV brackets when fixed directly on the soil.

Soiling monitoring

To monitor the soiling on the PV module, two reference cells are placed besides the module. One of them is kept clean, while the second is left in the natural condition, the difference between the modules performance is an index of the soiling of the module.

Diffuse Radiation

Obtained through 4 different ways:

- PRRDA3960 sensor for diffuse radiation
- Pyranometer and shadow band
- Pyrheliometer on a sun tracker with the shading ball
- Calculated by Alpha Log data logger knowing the global and direct radiation and the sun elevation

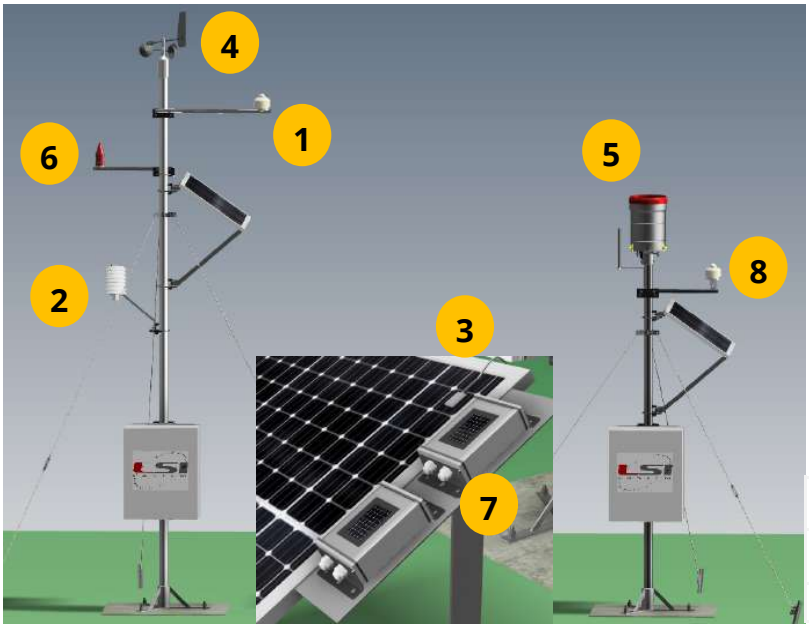
Pyranometer inclination

Pyranometers can be mounted on a horizontal arm to measure the Global Horizontal Irradiance (GHI) or on a tilted arm to measured the Tilted Global Irradiance (POA). Tilting arms are available also for two pyranometers in the same location (redundancy).

ALL-IN-ONE

If a compact solution is needed, All-In_one sensors are extremely compact and allow to monitor several environmental parameters at the same time: temperature, humidity, pressure, wind drection and wind speed (optional models with optic rain sensor or global radiometer).

Meteorological Station Kit



The meteorological modular station for PV plants can be designed with two boxes and two poles. The first pole supports the datalogger and some sensors (Pyranometer, Temperature sensor, storm distance sensor), while on the second pole, the ALIEM module is connected to a rain gauge, a diffuse radiation sensor, a surface temperature sensor and to the reference cells for soiling monitoring. Other meteorological sensors are available and can be added. If a compact solution is needed, the ALL-IN-ONE sensor can be the choice.

NOTES	
A	Cable length is function of poles distance
B	If a remote data management is needed

Drw. Ref.	PN	Description	Kit1	Ref. Notes
		A-Log data Logger (see catalogue MW9005-ENG-01)		
	DLALB0100	Alpha-Log/400MB/n.2 RS232/n.1 RS485/n.2 USB/n.1 Ethernet	1	
	MDMMB1110	Alpha-Log/Inputs extension/N.8 Analog.+4 Digitals/RS232-Modbus	2	
		RS485 converter		
	DEA504	RS232->485 converter/DIN bar	1	
	MN1510	Cable/Lan 4X2Xawg24/I-S/Ftp-Cmx Cat5-Sch	1	A
		Modem (see catalogue MW9005-ENG-07)	Optional	B
	TXCMA2200	Modem/4G/Antenna+Cable/12V	1	
	DEA611	External antenna 2DB/5 m cable/support	1	
		Software (see catalogue MW9006-ENG-03, 04)		B
	BSZ309	SW PluviONE CommNET	1	
	BSZ311	SW Gidas-Viewer	1	
		IP66 enclosure (see catalogue MW9005-ENG-07)		
	ELF340	Box IP66/50x40x16cm/230V->13,8V/50W/batt.2Ah	2	
	DYA074	Arm/ELFxxx/to D=45÷65mm.pole	2	
		Solar panel 60 W (see catalogue MW9005-ENG-07)	Optional	
	DYA101	Solar pannel/60W/cable L=5m	2	
	DYA064	Arm/Solar panel/to D=45÷65mm pole	2	
1		**Pyranometers (options Spectrally Flat Class A, B, C) (see catalogue MW9000-ENG-11)**		
		Spectrally Flat Class A		
	DPA252	Sensor/Pyranometer/Secondary Standard/µV	1	
	DWA205	Cable/L=5m/DPA252-952	1	
		Spectrally Flat Class B	Altern. to Class A	
	DPA154A	Sensor/Pyranometer/First Class/µV/Cable L=10 m	1	
		Mounting Accessories for DPA154 and DPA252 Horizontal		
	DYA034	Arm/DPA154-855-870-863-873-252-952-817- 822/Horiz./to DYA049	1	
	DYA049	Collar/for sensor arm to D=45÷65mm pole	1	

Drw. Ref.	PN	Description	Kit1	Ref. Notes
		Mounting Accessories for DPA154 and DPA252 Tilt	Altern. To Horizontal	
	DYA035	Arm/DPA154-855-870-863-873-252-952-817- 822/Tilt/to DYA049	1	
	DYA049	Collar/for sensor arm to D=45÷65mm pole	1	
		Spectrally Flat Class C	Altern. to Class A, B	
	DPA053	Sensor/Pyranometer/Second Class/µV/Cable L=5 m	1	
		Mounting accessories for DPA053 Horizontal		
	DYA032	Arm/DPA053-008, ESR003, DQA601, DMA131/ to DYA049	1	
	DYA049	Collar/for sensor arm to D=45÷65mm pole	1	
		Mounting accessories for DPA053 Tilt	Altern. To Horizontal	
	DYA048	Arm/DPA053/to DYA035	1	
	DYA035	Arm/DPA154-855-870-863-873-252-952-817- 822/Tilt/to DYA049	1	
	DYA049	Collar/for sensor arm to D=45÷65mm pole	1	
2		**Air temperature sensor (see catalogue MW9000-ENG-01)**		
	DMA033A	Sensor/Air Temp/Pt100/Cable L.5 m	1	
	DYA230	Radiant screen/NV/DMA67x-033	1	
	DYA049	Collar/for sensor arm to D=45÷65mm pole	1	
3		**Contact temperature sensor (see catalogue MW9000-ENG-04)**		
	DLE124A	Sensor/Surface Temp/Pt100/Cable L.20 m	1	
		Wind speed sensor - Compact version (Hz output) (see catalogue MW9000-ENG-09)	Optional	
	DNA202.1	Sensor/Cup-anem.-Compact/WS/Hz/7pin	1	
	DWA505A	Cable/L=5m/sensors	1	
4		**Wind speed&direction (see catalogue MW9000-ENG-04)**	Altern. To Wind Speed Sensor	
	DNA121	Sensor/cup&vane anem./WS+WD/Hz+0÷1V/ 10÷30V	1	
	DWA505A	Cable/L=5m/sensors	1	
5		**Rain gauge (Tipping bucket) (see catalogue MW9000-ENG-18)**	Optional	
	DQA230.1	Sensor/Rain gauge/324cmq/Siphone/Hz	1	
	DYA040.2	Arm/DQA230-231/to D=50mm.pole	1	
	DYA058	Lateral arm/D=50 mm.sensors/to D=45÷65mm. pole	1	
	DWA505A	Cable/L=5m/sensors	1	
6		**Storm Front distance sensor (see catalogue MW9000-ENG-21)**	Optional	
	DQA601.3	Sensor/Front distance/UART-TTL/5÷24V	1	
	DYA032	Arm/DPA053-008, ESR003, DQA601, DMA131/ to DYA049	1	
	DYA049	Collar/for sensor arm to D=45÷65mm pole	1	

Drw. Ref.	PN	Description	Kit1	Ref. Notes
7		**Reference Cell (see catalogue MW9000-ENG-12)**	Optional	
	DPA048.1	Sensor/ISET radiom.cell/monicristalline/Cable L=3 m/Calib.	2	
	DPA048.2	Sensore/ISET radiom.cell/policristalline/Cable L=3 m/Calib.	Altern. To DPA048.1	
	DPA048.3	Sensor/ISET radiom.cell/amorfo/Cable L=3 m/Calib.	Altern. To DPA048.1	
8		**Diffuse Radiation Sensor**	Optional	
	PRRDA3960	Diffuse radiation sensor, analog output	1	
	MAARA1001	Horizontal arm for PRRDA3960 sensor fixing, l=1 m	1	
	CCDTA0101	RS232 extension cable for sensor PRRDA3960, length 10 m	1	
		Pole H.3 m (see catalogue MW9007-ENG-01)		
	DYA010.1	Pole/H=3m/D=50mm	2	
	DYA020	Tripod/concrete installation/pole D= 50 mm	2	
	DYA020.1	Anchoring bolts for tripod/3 set	2	
	DYA028	Tie rods/H=2-3m	2	

Field system for PV Performance Ratio application

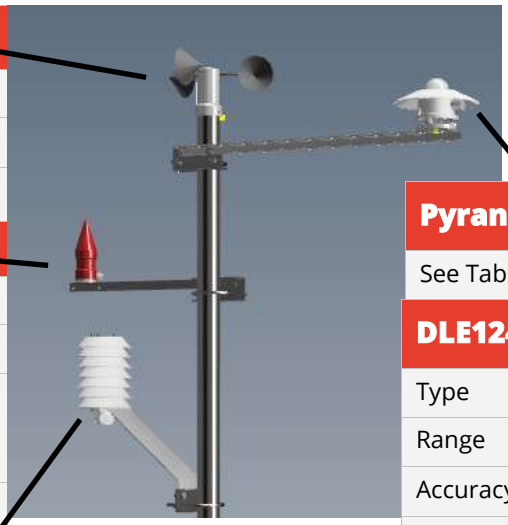
- Sensors kit for Performance Ratio calculation
- N.1 high-resolution input (18 bit) for Pyranometer (µV, mV) or 0÷1V. Configurable pyranometer sensitivity value
- N.2 Pt100 inputs (3-wire) with 0,5°C accuracy
- N.1 included internal Pt100 temperature sensor as alternative to external sensor. Thermistor input also available (DEA420.2 with 4÷20mA output)
- N.1 pulse/frequency input for LSI LASTEM wind speed sensors (DNA202-30x)
- N.1 RS232 input for Storm Distance Sensor (DQA601.1)
- RS485 (2-wire) Modbus RTU® port with galvanic insulation
- Model with 4÷20mA available (DEA420.1 with Pt100 input, DEA420.2 with thermistor input)

Modbus Sensor Box module is the simplest and fastest way to connect environmental sensors to PLC/SCADA systems by Modbus RTU. The module can be easily interfaced to Global Irradiance sensors, each with its own sensitivity value, temperature sensors (air and PV module surface), anemometers or a front distance sensor. Modbus Sensor Box module guarantees the benefits of a standard communication protocol well-proven by years of field testing: Modbus RTU®. MSB module can be connected to LSI LASTEM sensors, but the input feature allows the use of practically all types of environmental sensors on the market. In particular, any pyranometer can be used, since you can set the typical sensitivity value of its thermopile.

DNA202.1—Wind Speed	
Type	Relay Reed
Range	0÷75 m/s
Accuracy	2,5%

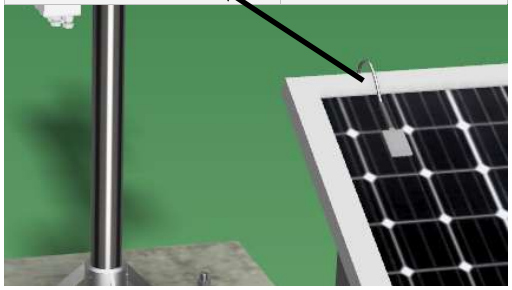
DQA601.3—Storm Distance	
Type	Sensitive RF receiver
Range	5÷40 km
Resolution	14 steps (5, 6, 8, 10, 12, 14, 17, 20, 24, 27, 31, 34, 37, 40 km)
Cable	L=5 m

DMA033—Air Temperature	
Type (Temp.)	C-MOS (Silicon)
Range (Temp.)	-20÷80°C
Accuracy (Temp.)	0,1°C (@0°C)

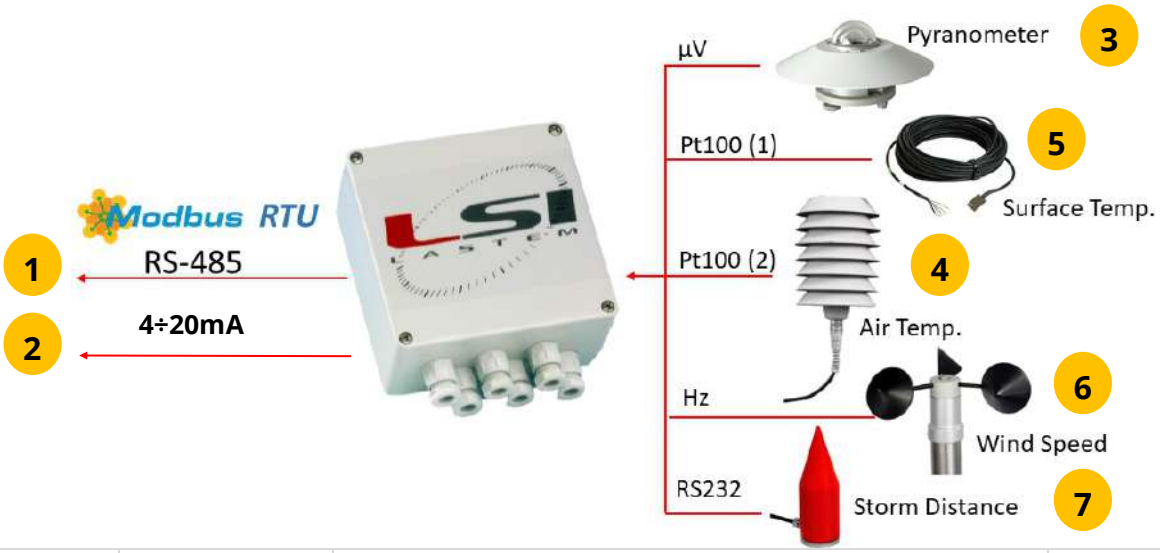


Pyranometer
See Table at pag.3 (only with µV output)

DLE124—Surface Temperature	
Type	Pt100
Range	-50÷70°C
Accuracy	0,1°C (@0°C)
Response time (T90)	35 s
Cable	L=20 m - Ø 5 mm



Performance Ratio Kit



Drw. Ref.	PN	Description	Kit1	Ref. Notes
		Modbus Sensor Box (see catalogue MW9008-ENG-05)		
1	**MDMMB1010.1**	MSB/N2 Pt100+mV+Hz/RS485/10÷30V	1	
2	**DEA420.1**	STB/N2 Pt100+mV+Hz/4x4÷20mA/10÷30V	Optional	A
2	**DEA420.2**	STB/Pt100+mV+Hz+TC/4x4÷20mA/10÷30V	Optional	B
		Accessory	Optional	
	DYA090	Arm/MSB÷STB/to D=45÷65mm.pole	1	
3		**Pyranometers (options Spectrally Flat Class A, B, C) (see catalogue MW9000-ENG-11)**		
		Spectrally Flat Class A		
	DPA252	Sensor/Pyranometer/Secondary Standard/µV	1	
	DWA205	Cable/L=5m/DPA252-952	1	
		Spectrally Flat Class B	Altern. To Class A	
	DPA154A	Sensor/Pyranometer/First Class/µV/Cable L=10 m		
		Mounting Accessories for DPA154 and DPA252 Horizontal		
	DYA034	Arm/DPA154-855-870-863-873-252-952-817- 822/Horiz./to DYA049	1	
	DYA049	Collar/for sensor arm to D=45÷65mm pole	1	
		Mounting Accessories for DPA154 and DPA252 Tilt	Altern. To Horizontal Arm	
	DYA035	Arm/DPA154-855-870-863-873-252-952-817- 822/Tilt/to DYA049	1	
	DYA049	Collar/for sensor arm to D=45÷65mm pole	1	
		Spectrally Flat Class C	Altern. To Class A, B	
	DPA053	Sensor/Pyranometer/Second Class/µV/Cable L=5 m	1	
		Mounting accessories for DPA053 Horizontal		
	DYA032	Arm/DPA053-008, ESR003, DQA601, DMA131/ to DYA049	1	
	DYA049	Collar/for sensor arm to D=45÷65mm pole	1	
		Mounting accessories for DPA053 Tilt	Altern. To Horizontal Arm	
	DYA048	Arm/DPA053/to DYA035	1	
	DYA035	Arm/DPA154-855-870-863-873-252-952-817- 822/Tilt/to DYA049	1	
	DYA049	Collar/for sensor arm to D=45÷65mm pole	1	

Drw. Ref.	PN	Description	Kit1	Ref. Notes
4		**Air temperature sensor (see catalogue MW9000-ENG-01)**		
	DMA033	Sensor/Air Temp/Pt100/Cable L.5 m	1	
	DYA230	Radiant screen/NV/DMA67x-033	1	
	DYA049	Collar/for sensor arm to D=45÷65mm pole	1	
5		**Contact temperature sensor (see catalogue MW9000-ENG-04)**		
	DLE124	Sensor/Surface Temp/Pt100/Cable L.20 m	1	
6		**Wind speed sensor - Compact version (Hz output) (see catalogue MW9000-ENG-09)**		
	DNA202.1	Sensor/Cup-anem.-Compact/WS/Hz/7pin	1	
	DWA505A	Cable/L=5m/sensors	1	
7		**Storm Front distance sensor (see catalogue MW9000-ENG-21)**	Optional	
	DQA601.3	Sensor/Front distance/UART-TTL/5÷24V	1	
	DYA032	Arm/DPA053-008, ESR003, DQA601, DMA131/ to DYA049	1	
	DYA049	Collar/for sensor arm to D=45÷65mm pole	1	
		Pole H.3 m (see catalogue MW9007-ENG-01)		
	DYA010.1	Pole/H=3m/D=50mm	1	
	DYA020	Tripod/concrete installation/pole D= 50 mm	1	
	DYA020.1	Anchoring bolts for tripod/3 set	1	
	DYA028	Tie rods/H=2-3m	1	

NOTES	
A	If option with 4÷20 mA is needed instead of RS485, input for Pt100
B	If option with 4÷20 mA is needed instead of RS485, input for thermistor

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